

PATENT ABSTRACTS OF JAPAN

(11)Publication number : 2003-164016
 (43)Date of publication of application : 06.06.2003

(51)Int.Cl.

B60L 15/20
B61C 15/12

(21)Application number : 2001-360444
 (22)Date of filing : 27.11.2001

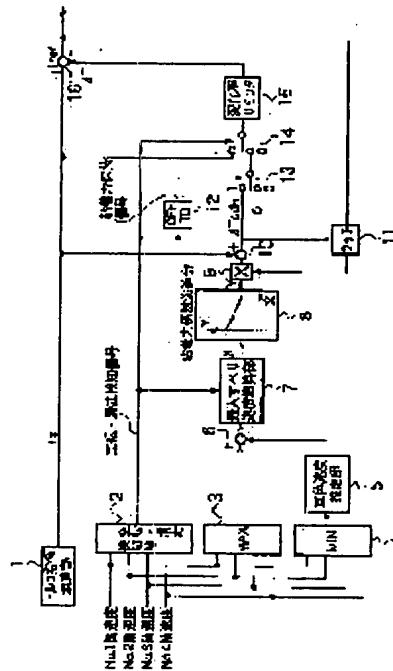
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(54) ELECTRIC ROLLING STOCK CONTROLLER

(57)Abstract:

PROBLEM TO BE SOLVED: To improve acceleration of a vehicle and comfortableness in ride by reducing frequency of occurrence of slipping/skidding of a drive shaft wheel.

SOLUTION: The electric rolling stock controller performs adhesion control which regulates torque if detecting slipping or skidding of an electric rolling stock, and later restores the torque. It monitors slipping or skidding of the drive shaft wheel, and if it detects the slipping or skidding, it calculates the maximum value of slipping velocity of the drive shaft wheel relative to a rail based on the vehicle velocity estimated from the rotational-speed signal of a motor and the rotational-speed signal of the motor. The adhesion factor is acquired from a pre-set function $Y=-AX+B$ (A and B are constants) in which X is maximum slipping velocity and Y is adhesion factor. A drive torque is regulated if slipping or skidding is detected. When calculating a target value to which the drive torque is later restored, the target value to which a torque is restored is raised if the adhesion factor is large, while the target value to which the torque is restored is made smaller if it is small.



LEGAL STATUS

[Date of request for examination] 25.05.2004

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number] 3798685

[Date of registration] 28.04.2006

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

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CLAIMS

[Claim(s)]

[Claim 1] In the electric-rolling-stock control unit which performs readhesion control to which racing or a skid of electric rolling stock is detected, torque is extracted, and torque is returned after that A racing / skid detection means to detect racing or a skid of a driving shaft wheel from the rotational frequency signal of a motor, Whenever [car-body-speed / which carries out the presumed operation of whenever / car-body-speed / from the rotational frequency signal of said motor] A presumed means, When said racing / skid detection means detects racing or a skid, from the rotational frequency signal of whenever [car-body-speed / for which a presumed means asks whenever / said car-body-speed], and said motor A maximum sliding-velocity operation means to calculate the maximum (the maximum sliding velocity) of sliding velocity to the rail of a driving shaft wheel, An adhesion multiplier operation means to ask for an adhesion multiplier by function $Y=-A-X+B$ (A, B constant) beforehand set up to sliding-velocity X of the adhesion multiplier Y by setting said maximum sliding velocity to X, When calculating the desired value to which racing or a skid is detected, driving torque is extracted, and driving torque is returned after that, It is the electric-rolling-stock control unit characterized by having the torque return desired value actuation means which enlarges desired value to which torque is returned according to the adhesion multiplier calculated with said adhesion multiplier operation means when an adhesion multiplier is large, and makes small desired value to which torque is returned when small.

[Claim 2] In the electric-rolling-stock control unit which performs readhesion control to which racing or a skid of electric rolling stock is detected, torque is extracted, and torque is returned after that A racing / skid detection means to detect racing or a skid of a driving shaft wheel from the rotational frequency signal of a motor, Whenever [car-body-speed / which carries out the presumed operation of whenever / car-body-speed / from the rotational frequency signal of said motor] A presumed means, Whenever [car-body-speed / for which a presumed means asks whenever / said car-body-speed / when said racing / skid detection means detects racing or a skid], and a sliding-velocity operation means to calculate the sliding velocity to the rail of a driving shaft wheel from the rotational frequency signal of said motor, When detecting racing or a skid, extracting a torque command and returning a torque command after that, The electric-rolling-stock control unit characterized by having a torque command actuation means to stop the motion to which it detects having become beyond the value to which the sliding velocity calculated with said sliding-velocity operation means was set beforehand, and a torque command is returned, and to hold the torque command value at the event.

[Claim 3] The electric-rolling-stock control unit characterized by making the function of the adhesion multiplier Y to maximum sliding-velocity X to the rail of a driving shaft wheel when racing or a skid occurs into $Y=A/(X+B)$ (A, B constant) in an electric-rolling-stock control unit according to claim 1.

[Claim 4] The electric-rolling-stock control unit characterized by setting the function of the adhesion multiplier Y to maximum sliding-velocity X to the rail of a driving shaft wheel when racing or a skid occurs to $Y=-A-X^2+B$ (A, B constant) in an electric-rolling-stock control unit according to claim 1.

[Claim 5] It is the electric-rolling-stock control unit characterized by resetting racing / skid detection signal if it becomes below a threshold with the speed difference of the wheel which will set racing / skid detection signal if the threshold in which said racing / skid detection means has the acceleration or deceleration of a wheel in an electric-rolling-stock control unit according to claim 1 is exceeded, and is driven by the adjustable electrical-potential-difference variable frequency method, and other wheels.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the electric-rolling-stock control unit which has the description in the readhesion control at the time of racing and a skid.

[0002]

[Description of the Prior Art] The example of readhesion control at the time of racing and the skid in the conventional electric-rolling-stock control unit is shown in drawing 12. two or more rotational frequency detectors 103 of a motor 102 driven with a power converter 101 — each rotational frequency signal is changed into a speed signal by the rate operation part 104. In racing / skid detection section 105, the rate rate of change of a speed signal is searched for, and racing and a skid are distinguished based on the rate rate of change. Torque drawing and the return operation part 106 calculate and output the amount of torque drawing, or the amount of returns according to this racing / skid distinction signal. The torque command pattern output section 107 outputs a torque command pattern. An adder 108 adds the output of tolyl drawing and the return operation part 106, and the output of the torque command pattern output section 107 (here, it subtracts), and outputs them as a converter torque command.

[0003] Drawing 13 explains these motions by making the time of racing into an example. an event — t11 — the flag of racing / skid detection — setting — readhesion control — starting — Event t — racing / skid detection was canceled to 12 — then, a torque command — the first-order lag of after that and a time constant tau — the original command value q0 It returns.

[0004] At this time, before returning [that the adhesion of a rail and a wheel has declined, and] to the original command value q0, it re-races (event t13), and readhesion control is performed again (event t14), and a torque command curve becomes likely to have shown in the alternate long and short dash line A of drawing 13.

[0005]

[Problem(s) to be Solved by the Invention] As mentioned above, in the readhesion control at the time of racing and the skid by the conventional electric-rolling-stock control unit, when the adhesion of a wheel declined by rainy weather etc., the event of racing → re-adhesion → racing was repeated frequently, and there was a trouble which causes acceleration performance degradation and lowering of a degree of comfort as electric rolling stock.

[0006] This invention was made in view of such a conventional trouble, reduces the occurrence frequency of racing and a skid, and aims at offering the electric-rolling-stock control unit which can aim at improvement in the acceleration engine performance and a degree of comfort.

[0007]

[Means for Solving the Problem] In the electric-rolling-stock control unit which performs readhesion control to which invention of claim 1 detects racing or a skid of electric rolling stock, and extracts torque, and torque is returned after that A racing / skid detection means to detect racing or a skid of a driving shaft wheel from the rotational frequency signal of a motor, Whenever [car-body-speed / which carries out the presumed operation of whenever / car-body-speed / from the rotational frequency signal of said motor] A presumed means, When said racing / skid detection means detects racing or a skid, from the rotational frequency signal of whenever [car-body-speed / for which a presumed means asks whenever / said car-body-speed], and said motor A maximum sliding-velocity operation means to calculate the maximum (the maximum sliding velocity) of sliding velocity to the rail of a driving shaft wheel, An adhesion multiplier operation means to ask for an adhesion multiplier by function $Y=-A-X+B$ (A, B constant) beforehand set up to sliding-velocity X of the adhesion multiplier Y by setting said maximum sliding velocity to X, When calculating the desired value to which racing or a skid is detected, driving torque is extracted, and driving torque is returned after that, According to the adhesion multiplier calculated with said adhesion multiplier operation means, when an adhesion multiplier is large, desired value to which torque is returned is enlarged, and when small, it has the torque return desired value actuation means which makes small desired value to which torque is returned.

[0008] In the electric-rolling-stock control unit which performs readhesion control to which invention of claim 2 detects racing or a skid of electric rolling stock, and extracts torque, and torque is returned after that A racing / skid detection means to detect racing or a skid of a driving shaft wheel from the rotational frequency signal of a motor, Whenever [car-body-speed / which carries out the presumed operation of whenever / car-body-speed / from the rotational frequency signal of said motor] A presumed means, Whenever [car-body-speed / for which a presumed means asks whenever / said car-body-speed / when said racing / skid detection means detects racing or a skid], and a sliding-velocity operation means to calculate the sliding velocity to the rail of a driving shaft wheel from the rotational frequency signal of said motor, When detecting racing or a skid, extracting a torque command and returning a torque command after that, The motion to which it detects having become beyond the value to which the sliding velocity calculated with said sliding-velocity operation means was set beforehand, and a torque command is returned is stopped, and it has a torque command actuation means to hold the torque command value at the event.

[0009] Invention of claim 3 is characterized by making the function of the adhesion multiplier Y to maximum sliding-velocity X to the rail of a driving shaft wheel when racing or a skid occurs into $Y=A/(X+B)$ (A, B constant) in an electric-rolling-stock control unit according to claim 1.

[0010] Invention of claim 4 is characterized by setting the function of the adhesion multiplier Y to maximum sliding-velocity X to the rail of a driving shaft wheel when racing or a skid occurs to $Y=-A-X^2+B$ (A, B constant) in an electric-rolling-stock control unit according to claim 1.

[0011] In an electric-rolling-stock control unit according to claim 1, invention of claim 5 will set racing / skid detection signal, if

said racing / skid detection means exceeds a threshold with the acceleration or deceleration of a wheel, and if it becomes below a threshold with the speed difference of the wheel currently driven by the adjustable electrical-potential-difference variable frequency method, and other wheels, it will be characterized by to reset racing / skid detection signal.

[0012]

[Embodiment of the Invention] Hereafter, the gestalt of operation of this invention is explained in full detail based on drawing. Drawing 1 shows the configuration of the 1st of the gestalt of operation of this invention. The torque command operation part 1 calculates the torque command T_s according to the notch command of a driver's stand. Racing / skid detection section 2 detects racing or a skid from the rate of each driving shaft of electric rolling stock, and outputs racing / skid detection signal. The maximum velocity operation part (MAX) 3 calculates the maximum of the rate of each driving shaft. The minimum rate operation part (MIN) 4 calculates the minimum value of the rate of each driving shaft. The presumed section 5 presumes the rate minimum value empty vehicle object rate which MIN4 calculated whenever [car-body-speed]. An adder 6 calculates the difference of the maximum velocity calculated by MAX3, and the minimum speed calculated by MIN5 as sliding velocity between a wheel and a rail.

[0013] The maximum sliding-velocity operation part 7 calculates maximum sliding-velocity X while racing / skid detection signal detected in racing / skid detection section 2 is outputted. The adhesion multiplier operation part 8 calculates the adhesion multiplier Y from the maximum sliding velocity calculated by the maximum sliding-velocity operation part 7. The torque command latch section 11 latches the torque command before racing in the standup of racing / skid detection signal detected by racing / skid detection section 2.

[0014] A multiplier 9 searches for T micro of adhesion from the adhesion multiplier Y for which the adhesion multiplier operation part 8 asked, and the torque command before racing which the torque command latch section 11 latched. An adder 10 deducts T micro of adhesion which this multiplier 9 outputs from the torque command T_s which the torque command operation part 1 calculated, and calculates amount of drawing ΔT_{adh} at the time of adhesion. While racing / skid detection signal detected in racing / skid detection section 2 is outputted, the amount change-over switch 14 of drawing of the preceding paragraph of the rate-of-change limiter 15 which outputs amount of drawing ΔT changes to the torque command T_s side, and amount of drawing ΔT which the rate-of-change limiter 15 outputs begins an increment toward the torque command T_s .

[0015] On the other hand, the OFF delay timer (OFFTD) 12 gives the off-delay of fixed time amount to racing / skid detection signal which racing / skid detection section 2 outputs. Then, if racing / skid detection signal is outputted from racing / skid detection section 2, this off-delay signal will change the output of the adhesion output change-over switch 13 to ΔT_{adh} as an adhesion maintenance signal. For this reason, if racing / skid detection signal from racing / skid detection section 2 is lost, amount change-over SUITCHI 14 of drawing will change to the output side of the adhesion change-over switch 13, the input of the rate-of-change limiter 15 will serve as ΔT_{adh} , and amount of drawing ΔT will decrease to ΔT_{adh} with a certain inclination.

[0016] Then, since an adhesion maintenance signal is canceled after fixed OFF delay time after racing / skid detection signal is canceled, the output of the adhesion change-over switch 13 is set to 0, and amount of drawing ΔT decreases with a certain inclination to 0.

[0017] The driving torque command T_{ref} is the value which deducted ΔT which the rate-of-change limiter 15 outputs from the torque command T_s which the torque command operation part 1 outputs with an adder 16. For this reason, if racing / skid detection section 2 detects racing, while racing / skid detection signal is outputted, it will decrease with a certain inclination, and it will return to T micro of adhesion with a certain inclination whose racing / skid detection signal is lost, and actuation of racing / skid detection signal being lost and returning to the original value after fixed time amount will be carried out.

[0018] Drawing 2 shows the detailed configuration of the presumed operation part 5 whenever [in drawing 1 / car-body-speed]. The acceleration operation part 21 calculates whenever [acceleration-and-deceleration / of the minimum speed inputted from the minimum rate operation part (MIN) 4]. Whenever [by racing and skid / steep acceleration-and-deceleration] is stopped with the first-order-lag filter 22, and a stable presumed rate is obtained by integrating an integrator 24. The acceleration amendment section 26 searches for a difference with the minimum speed inputted as the presumed rate which an integrator 24 outputs, and amends the acceleration which the acceleration operation part 21 outputs in an adder 23, and it prevents the presumed rate which an integrator 24 finds being greatly different widely from a minimum speed.

[0019] In the minimum value operation part (MIN) 25, when a presumed rate prevents becoming larger than a minimum speed and becomes large about it, an integrator 24 and the first-order-lag filter 22 are preset so that estimate may be [whenever / car-body-speed] in agreement with a minimum speed.

[0020] Drawing 3 shows the example of the adhesion multiplier operation expression which the adhesion multiplier operation part 8 in drawing 1 performs. When the time of rail desiccation is set to 1.0, sliding-velocity X is $X > X_0$. In a field, -izing can be carried out [function] in $Y = -A - X + B$. In an artificer's experimental result, $X_0 = 0.25$ km/h, $A = 0.09$, and $B = 0.83$ are obtained.

[0021] Drawing 4 and drawing 5 show the experimental data which measured the relation between the adhesion at the time of transit, and the sliding velocity between a rail and a wheel on the conditions which sprinkled the wheel. About these averages, the property which changed the value at the time of rail desiccation as 1.0, and plotted it to sliding velocity becomes like the graph of drawing 3.

[0022] Next, actuation of the gestalt of the above-mentioned operation is explained using drawing 6. if racing / skid detection signal occurs by racing / skid detection section 2 at the t2 event, the driving torque command value T_{ref} at the event be alike torque command latch section 11 — it is latched as L_i Treflatch. Then, the amount of torque drawing is made to increase with a certain inclination by the adhesion multiplier operation part 8, and the driving torque command T_{ref} is reduced. The maximum sliding velocity X_1 until racing / skid detection signal is canceled at the t3 event It calculates by the maximum sliding-velocity operation part 7, and is the output Y_1 of the adhesion multiplier operation part 9. It is operation *** by the property of drawing 3. Namely, the maximum sliding velocity X_1 Adhesion multiplier Y_1 It is the adhesion multiplier Y_1 to driving torque Treflatch which was set to $Y_1 = -A - X_1 + B$ and was latched at the time of racing / skid detection. It hangs and calculates by $T_{mu} = Y_1$ and Treflatch.

[0023] If racing / skid detection signal is canceled at the t3 event, in order that the output of the adhesion multiplier operation part 9 may decrease toward adhesion ΔT_{adh} , as shown all over drawing, the driving torque command T_{ref} goes up toward T micro. In other words, a wheel re-adheres to a rail and a torque command value when racing / skid detection signal is canceled turns into a value of T micro which applied the adhesion multiplier to the torque command value when detecting racing.

[0024] According to the gestalt of operation of the 1st of this invention, since adhesion is calculated from the maximum sliding velocity before a torque command return, setting out of the resetting value of the driving torque command in consideration of the adhesion condition between the newest rail and wheel is attained.

[0025] Next, the gestalt of operation of the 2nd of this invention is explained using drawing 7. In drawing 6, the same sign is given to the element which was shown in drawing 1 and which is common in the gestalt of the 1st operation. The elements which were shown in drawing 1 and which were added to the gestalt of the 1st operation are the return torque attaching part 17, the sliding-velocity buildup detection section 18, and a logical circuit 19.

[0026] The return torque attaching part 17 has the function to stop reduction of the amount of torque drawing with a return stop signal. The sliding-velocity buildup detection section 18 similarly added detects buildup of the maximum sliding velocity which the maximum sliding-velocity operation part 7 outputs, and outputs a sliding-velocity buildup detection signal, and a logical circuit 19 calculates AND of the NOT signal and sliding-velocity buildup detection signal over the adhesion maintenance signal of the OFF delay timer 12. Although the return torque attaching part 17 serves to stop reduction of the amount of torque drawing with a return stop signal, this return stop signal is a signal materialized on condition that the AND of there not being a sliding-velocity buildup detection signal which is the output of a logical circuit 19, and an adhesion maintenance signal.

[0027] Thereby, after racing / skid detection, since a return stop signal is not outputted until an adhesion maintenance signal is lost, the adhesion based on the multiplier calculated by the adhesion multiplier operation part 8 is secured. In an artificer's experimental result, the result that the delay time of OFFTD12 when the threshold of which the threshold of the sliding velocity which outputs a return stop signal cancels 0.5 km/h and a return stop signal holds 0.3 km/h and an adhesion maintenance signal is desirable for 3 seconds is obtained.

[0028] Actuation of the gestalt of the 2nd operation is explained using drawing 6 like the gestalt of the 1st operation. If an adhesion maintenance signal is lost at the t5 event and the amount of torque drawing begins reduction, driving torque will go up and racing will be again begun at the t6 event which become beyond the adhesion between a rail and a wheel. Sliding velocity rises and the actuation which decreases the amount of torque drawing is suspended at the t7 event which become beyond the set value which outputs a return stop signal. Then, a driving torque command begins lifting again at the t8 event from which sliding velocity becomes below the reset value of which a return stop signal is canceled.

[0029] Since according to the gestalt of operation of the 2nd of this invention sliding velocity is supervised and the increment in a torque command is controlled, sliding velocity increases and it can prevent that racing and a skid occur again.

[0030] Next, the gestalt of operation of the 3rd of this invention is explained using drawing 8. $Y=A/(X+B)$ as shown in the graph of drawing 8 can be made to perform the operation [in / on the gestalt of the 2nd operation, and / the adhesion multiplier operation part 8] of the adhesion multiplier Y which was shown in drawing 1 and to which it was shown in the gestalt or drawing 7 of the 1st operation. Thereby, it is the maximum sliding velocity X1. Adhesion multiplier $Y1 </SUB>$ is calculated by $Y1 = A/(X1+B)$. However, A and B are constants.

[0031] Drawing 8 is a graph at the time of considering as $B=A$. According to this drawing 8, an adhesion multiplier becomes small by reverse proportion mostly, so that the maximum sliding velocity increases.

[0032] Next, the gestalt of operation of the 4th of this invention is explained using drawing 9. $Y=-A-X2+B$ (A, B constant) as shown in the graph of drawing 9 can also be made to perform the operation [in / on the gestalt of the 2nd operation, and / the adhesion multiplier operation part 8] of the adhesion multiplier Y which was shown in drawing 1 and to which it was shown in the gestalt or drawing 7 of the 1st operation. Thereby, it is the ***** Berry rate X1. Adhesion multiplier $Y1$ It calculates by $Y1 = -A-X1 2+B$ (A, B constant).

[0033] Drawing 9 is the case where it is referred to as $B=1.0$. According to this drawing 9, an adhesion multiplier becomes small in proportion to the 2nd [about] power, so that the maximum sliding velocity increases.

[0034] Next, the gestalt of operation of the 5th of this invention is explained using drawing 10. Drawing 10 shows the detailed configuration of racing / skid detection section 2 which transposes to each racing / skid detection section 2, and can be adopted as it in the electric-rolling-stock control unit of the gestalt of the 2nd operation which was shown in drawing 1 and which was shown in the gestalt of the 1st operation, and drawing 7.

[0035] Racing / skid detection section 2 of the gestalt of this operation shows the case where No.1 shaft is driven by VVVF (adjustable electrical-potential-difference variable frequency method). The acceleration of No.1 shaft is calculated by the acceleration operation part 31, and the output is inputted into racing / skid detection comparator 32. This comparator 32 will output "H", if the acceleration inputted is over the detection threshold of racing and a skid, and it sets it to S input of racing / skid detection signal creation flip-flop 35. Consequently, racing / skid detection signal which is the output of a flip-flop 35 is set to "H".

[0036] Estimate is incorporated whenever [car-body-speed / for which the presumed section 5 asks whenever / car-body-speed / on the other hand from the rate minimum value of the No.1 shaft rate which the minimum rate operation part 4 outputs - the No.4 shaft rates], and a difference with estimate, i.e., sliding velocity, is searched for a No.1 shaft rate and whenever [this car-body-speed] in an adder 33. Racing / skid discharge comparator 34 inputs the sliding velocity which this adder 33 outputs. And a comparator 34 will set "H" to R input of racing / skid detection signal creation flip-flop 35, if sliding velocity is a value below racing / skid signal discharge threshold. Consequently, racing / skid detection signal which is the output of a flip-flop 35 is set to "L".

[0037] Drawing 11 shows the racing / skid detection approach by the racing operation part 2 of drawing 10. If No.1 shaft races and the acceleration becomes more than racing / skid detection threshold, racing / skid detection signal will be set to "H." If No.1 shaft re-sticks and the difference of a No.1 shaft rate and whenever [car-body-speed], i.e., sliding velocity, becomes below racing / skid signal discharge threshold, racing / skid detection signal will be set to "L." According to this operation, re-adhesion can be detected certainly and re-racing can be prevented rather than it performs racing / skid detection only with acceleration.

[0038]

[Effect of the Invention] By this invention, the re-adhesion property at the time of racing and a skid can be improved, racing / skid frequency can be reduced, and the acceleration engine performance and degree of comfort as electric rolling stock can be raised.

[0039] In the electric-rolling-stock control unit which performs readhesion control to which racing or a skid of electric rolling stock is detected, torque is extracted, and torque is especially returned after that according to invention of claims 1, 3, and 4. When racing or a skid of a driving shaft wheel is supervised and racing or a skid is detected From the rotational frequency signal of whenever [car-body-speed / which was presumed from the rotational frequency signal of a motor], and a motor, calculate the maximum of sliding velocity to the rail of a driving shaft wheel, and the maximum sliding velocity is further set to X. By function $Y=-A-X+B$ (A, B constant) beforehand set up to sliding-velocity X of the adhesion multiplier Y Or $Y=A/(X+B)$ (A, B constant), Or it asks for an adhesion multiplier by $Y=-A-X2+B$ (A, B constant). When calculating the desired value to which racing

or a skid is detected, driving torque is extracted, and driving torque is returned after that. Since desired value to which torque is returned was enlarged, and it was made to make small desired value to which torque is returned when small when this adhesion multiplier was large. Setting out of the resetting value of the driving torque command in consideration of the adhesion condition between the newest rail and wheel is possible, the re-adhesion property at the time of racing and a skid can be improved, racing / skid frequency can be reduced, and the acceleration engine performance and degree of comfort as electric rolling stock can be raised.

[0040] Moreover, according to invention of claim 2, it sets to the readhesion control to which racing or a skid of electric rolling stock is detected, torque is extracted, and torque is returned after that. Detect racing or a skid of a driving shaft wheel from the rotational frequency signal of a motor, and the presumed operation of whenever [car-body-speed] is carried out from the rotational frequency signal of a motor. When racing or a skid is detected, from the rotational frequency signal of whenever [car-body-speed], and a motor Calculate the sliding velocity to the rail of a driving shaft wheel, detect racing or a skid, and a torque command is extracted. Since the motion to which it detects having become beyond the value to which sliding velocity was set beforehand, and a torque command is returned is stopped and the torque command value at the event was held when returning a torque command after that. Sliding velocity can be supervised, the increment in a torque command can be controlled, sliding velocity increases, and it can prevent that racing and a skid occur again.

[0041] Furthermore, since racing / skid detection signal was made reset according to invention of claim 5 when becoming below a threshold with the speed difference of the wheel which will set racing / skid detection signal if a threshold with the acceleration or the deceleration of a wheel is exceeded, and is driven by the adjustable electrical-potential-difference variable-frequency method, and other wheels, re-adhesion can be detected certainly and re-racing can protect rather than it carries out racing / skid detection only at acceleration.

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] The block diagram of the gestalt of operation of the 1st of this invention.

[Drawing 2] It is the block diagram of the presumed section whenever [in the gestalt of the above-mentioned operation / car-body-speed].

[Drawing 3] The graph of the operation expression which adhesion multiplier operation part uses in the gestalt of the above-mentioned operation.

[Drawing 4] The graph which shows the actual measurement of the adhesion and sliding velocity in water spray conditions in the gestalt of the above-mentioned operation (the 1).

[Drawing 5] The graph which shows the actual measurement of the adhesion and sliding velocity in water spray conditions in the gestalt of the above-mentioned operation (the 2).

[Drawing 6] The timing chart which shows actuation for the readhesion control property of the gestalt of operation of the 1st of this invention, and the gestalt of the 2nd operation.

[Drawing 7] The block diagram of the gestalt of operation of the 2nd of this invention.

[Drawing 8] The graph of the operation expression which adhesion multiplier operation part uses in the gestalt of operation of the 3rd of this invention.

[Drawing 9] The graph of the operation expression which adhesion multiplier operation part uses in the gestalt of operation of the 4th of this invention.

[Drawing 10] The block diagram of racing / skid detection section in the gestalt of operation of the 5th of this invention.

[Drawing 11] The timing chart of racing / skid detection actuation by the gestalt of the above-mentioned operation.

[Drawing 12] The block diagram of the configuration of the conventional example.

[Drawing 13] The timing chart which shows justice actuation of the conventional example.

[Description of Notations]

1 Torque Command Operation Part

2 Racing / Skid Detection Section

3 Maximum Velocity Operation Part

4 The Minimum Rate Operation Part

5 It is Presumed Section whenever [Car-Body-Speed].

6 Adder

7 The Maximum Sliding-Velocity Operation Part

8 Adhesion Multiplier Operation Part

9 Multiplier

10 Adder

11 Torque Command Latch Section

12 OFF Delay Timer

13 The Amount Change-over Switch of Drawing

14 Adhesion Change-over Switch

15 Rate-of-Change Limiter

16 Adder

17 Return Torque Attaching Part

18 Sliding-Velocity Buildup Detection Section

19 Logical Circuit

31 Acceleration Operation Part

32 Racing / Skid Detection Comparator

33 Racing / Skid Discharge Comparator

35 Flip-flop

[Translation done.]

【特許請求の範囲】

【請求項1】 電気車の空転又は滑走を検知してトルクを絞り、その後トルクを復帰させる再粘着制御を行う電気車制御装置において、電動機の回転数信号より駆動軸車輪の空転又は滑走を検知する空転・滑走検知手段と、前記電動機の回転数信号より車体速度を推定演算する車体速度推定手段と、前記空転・滑走検知手段が空転又は滑走を検知した時に、前記車体速度推定手段の求める車体速度と前記電動機の回転数信号より、駆動軸車輪のレールに対するすべり速度の最大値（最大すべり速度）を演算する最大すべり速度演算手段と、

前記最大すべり速度をXとして、粘着力係数Yのすべり速度Xに対してあらかじめ設定してある関数 $Y = -A \cdot X + B$ （A, B定数）により粘着力係数を求める粘着力係数演算手段と、

空転又は滑走を検知して駆動トルクを絞り、その後駆動トルクを復帰させる目標値を演算する際、前記粘着力係数演算手段により演算された粘着力係数に応じて粘着力係数が大きい時はトルクを復帰させる目標値を大きくし、小さい時はトルクを復帰させる目標値を小さくするトルク復帰目標値操作手段とを備えたことを特徴とする電気車制御装置。

【請求項2】 電気車の空転又は滑走を検知してトルクを絞り、その後トルクを復帰させる再粘着制御を行う電気車制御装置において、

電動機の回転数信号より駆動軸車輪の空転又は滑走を検知する空転・滑走検知手段と、

前記電動機の回転数信号より車体速度を推定演算する車体速度推定手段と、

前記空転・滑走検知手段が空転又は滑走を検知した時に、前記車体速度推定手段の求める車体速度と前記電動機の回転数信号より、駆動軸車輪のレールに対するすべり速度を演算するすべり速度演算手段と、

空転又は滑走を検知してトルク指令を絞り、その後トルク指令を復帰させる際、前記すべり速度演算手段で演算したすべり速度が予め設定された値以上になったことを検知してトルク指令を復帰させる動きを停止し、その時点のトルク指令値を保持するトルク指令操作手段とを備えたことを特徴とする電気車制御装置。

【請求項3】 請求項1記載の電気車制御装置において、

空転又は滑走が発生した時の駆動軸車輪のレールに対する最大すべり速度Xに対する粘着力係数Yの関数を、 $Y = A / (X + B)$ （A, B定数）としたことを特徴とする電気車制御装置。

【請求項4】 請求項1記載の電気車制御装置において、

空転又は滑走が発生した時の駆動軸車輪のレールに対す

る最大すべり速度Xに対する粘着力係数Yの関数を、 $Y = -A \cdot X^2 + B$ （A, B定数）としたことを特徴とする電気車制御装置。

【請求項5】 請求項1記載の電気車制御装置において、

前記空転・滑走検知手段は、車輪の加速度あるいは減速度があるしきい値を超えた空転・滑走検知信号をセットし、可変電圧可変周波数方式で駆動されている車輪と他の車輪との速度差があるしきい値以下になったら空転・滑走検知信号をリセットすることを特徴とする電気車制御装置。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】 本発明は空転・滑走時の再粘着制御に特徴を有する電気車制御装置に関する。

【0002】

【従来の技術】 図12に従来の電気車制御装置における空転・滑走時の再粘着制御例を示す。電力変換器101で駆動される複数台のモータ102の回転数検出器103各々の回転数信号を速度演算部104にて速度信号に変換する。空転・滑走検知部105では速度信号の速度変化率を求め、その速度変化率に基づいて空転・滑走を判別する。トルク絞り・復帰演算部106はこの空転・滑走判別信号に応じて、トルク絞り量あるいは復帰量を演算して出力する。トルク指令パターン出力部107はトルク指令パターンを出力する。加算器108はトリル絞り・復帰演算部106の出力とトルク指令パターン出力部107の出力を加算（ここでは減算）し、変換器トルク指令として出力する。

【0003】 図13は、空転時を例としてこれらの動きを説明したものである。時点t11に空転・滑走検知のフラグをセットして再粘着制御を開始し、時点t12に空転・滑走検知を解除したとすれば、トルク指令はその後、時定数τの一次遅れで元の指令値 q_0 に復帰する。

【0004】 このとき、レールと車輪の粘着力が低下したままであると、元の指令値 q_0 に戻る前に再空転し（時点t13）、再び再粘着制御が実行され（時点t14）、トルク指令カーブは、図13の一点鎖線Aに示した動きとなる。

【0005】

【発明が解決しようとする課題】 上述のように、従来の電気車制御装置による空転・滑走時の再粘着制御では、雨天などで車輪の粘着力が低下すると、空転→再粘着→空転の事象が頻繁に繰り返され、電気車として加速性能の低下、乗り心地の低下を招く問題点があった。

【0006】 本発明は、このような従来の問題点に鑑みてなされたもので、空転・滑走の発生頻度を低減し、加速性能及び乗り心地の向上が図れる電気車制御装置を提供することを目的とする。

【0007】

【課題を解決するための手段】請求項1の発明は、電気車の空転又は滑走を検知してトルクを絞り、その後トルクを復帰させる再粘着制御を行う電気車制御装置において、電動機の回転数信号より駆動軸車輪の空転又は滑走を検知する空転・滑走検知手段と、前記電動機の回転数信号より車体速度を推定演算する車体速度推定手段と、前記空転・滑走検知手段が空転又は滑走を検知した時に、前記車体速度推定手段の求める車体速度と前記電動機の回転数信号より、駆動軸車輪のレールに対するすべり速度の最大値（最大すべり速度）を演算する最大すべり速度演算手段と、前記最大すべり速度をXとして、粘着力係数Yのすべり速度Xに対してあらかじめ設定してある関数 $Y = -A \cdot X + B$ （A, B定数）により粘着力係数を求める粘着力係数演算手段と、空転又は滑走を検知して駆動トルクを絞り、その後駆動トルクを復帰させる目標値を演算する際、前記粘着力係数演算手段により演算された粘着力係数に応じて粘着力係数が大きい時はトルクを復帰させる目標値を大きくし、小さい時はトルクを復帰させる目標値を小さくするトルク復帰目標値操作手段とを備えたものである。

【0008】請求項2の発明は、電気車の空転又は滑走を検知してトルクを絞り、その後トルクを復帰させる再粘着制御を行う電気車制御装置において、電動機の回転数信号より駆動軸車輪の空転又は滑走を検知する空転・滑走検知手段と、前記電動機の回転数信号より車体速度を推定演算する車体速度推定手段と、前記空転・滑走検知手段が空転又は滑走を検知した時に、前記車体速度推定手段の求める車体速度と前記電動機の回転数信号より、駆動軸車輪のレールに対するすべり速度を演算するすべり速度演算手段と、空転又は滑走を検知してトルク指令を絞り、その後トルク指令を復帰させる際、前記すべり速度演算手段で演算したすべり速度が予め設定された値以上になったことを検知してトルク指令を復帰させる動きを停止し、その時点のトルク指令値を保持するトルク指令操作手段とを備えたものである。

【0009】請求項3の発明は、請求項1記載の電気車制御装置において、空転又は滑走が発生した時の駆動軸車輪のレールに対する最大すべり速度Xに対する粘着力係数Yの関数を、 $Y = A / (X + B)$ （A, B定数）としたことを特徴とするものである。

【0010】請求項4の発明は、請求項1記載の電気車制御装置において、空転又は滑走が発生した時の駆動軸車輪のレールに対する最大すべり速度Xに対する粘着力係数Yの関数を、 $Y = -A \cdot X^2 + B$ （A, B定数）としたことを特徴とするものである。

【0011】請求項5の発明は、請求項1記載の電気車制御装置において、前記空転・滑走検知手段は、車輪の加速度あるいは減速度があるしきい値を超えた空転・滑走検知信号をセットし、可変電圧可変周波数方式で駆動されている車輪と他の車輪との速度差があるしきい値

以下になつたら空転・滑走検知信号をリセットすることを特徴とするものである。

【0012】

【発明の実施の形態】以下、本発明の実施の形態を図に基づいて詳説する。図1は本発明の第1の実施の形態の構成を示している。トルク指令演算部1は運転台のノッチ指令に応じたトルク指令 T_s を演算する。空転・滑走検知部2は電気車の各駆動軸の速度から空転又は滑走を検知し、空転・滑走検知信号を出力する。最大速度演算部(MAX)3は各駆動軸の速度の最大値を演算する。最低速度演算部(MIN)4は各駆動軸の速度の最小値を演算する。車体速度推定部5はMIN4の演算した速度最小値から車体速度を推定する。加算器6は、MAX3で演算された最大速度とMIN5で演算された最小速度との差を、車輪とレール間のすべり速度として演算する。

【0013】最大すべり速度演算部7は、空転・滑走検知部2で検知された空転・滑走検知信号が出力されている間の最大すべり速度Xを演算する。粘着力係数演算部8は、最大すべり速度演算部7で演算された最大すべり速度から粘着力係数Yを演算する。トルク指令ラッチ部11は、空転・滑走検知部2により検知された空転・滑走検知信号の立ち上がりで空転前のトルク指令をラッチする。

【0014】乗算器9は、粘着力係数演算部8の求めた粘着力係数Yとトルク指令ラッチ部11のラッチした空転前のトルク指令とから粘着力 T_μ を求める。加算器10は、トルク指令演算部1の演算したトルク指令 T_s からこの乗算器9の出力する粘着力 T_μ を差し引いて粘着時の絞り量 ΔT_{adh} を求める。空転・滑走検知部2で検知された空転・滑走検知信号が出力されている間、絞り量 ΔT を出力する変化率リミッタ15の前段の絞り量切換スイッチ14がトルク指令 T_s 側に切り替わり、変化率リミッタ15の出力する絞り量 ΔT はトルク指令 T_s に向かって増加を始める。

【0015】一方、オフディレイタイマ(OFF TD)12は、空転・滑走検知部2の出力する空転・滑走検知信号に一定時間のOFFディレイを持たせる。そこで、空転・滑走検知部2から空転・滑走検知信号が出力されれば、このOFFディレイ信号は粘着力保持信号として粘着力出力切換スイッチ13の出力は ΔT_{adh} に切り替える。このため、空転・滑走検知部2からの空転・滑走検知信号がなくなると、絞り量切換スイッチ14は粘着力切換スイッチ13の出力側に切り替わり、変化率リミッタ15の入力は ΔT_{adh} となり、絞り量 ΔT はある傾きで ΔT_{adh} まで減少する。

【0016】その後、粘着力保持信号は、空転・滑走検知信号が解除されてから一定のOFFディレイ時間後に解除されるので、粘着力切換スイッチ13の出力は0となり、絞り量 ΔT は0まである傾きで減少する。

【0017】駆動トルク指令 T_{ref} は、加算器 16 によりトルク指令演算部 1 の出力するトルク指令 T_s から変化率リミッタ 15 の出力する ΔT を差し引いた値である。このため、空転・滑走検知部 2 が空転を検知すると、空転・滑走検知信号が output されている間はある傾きで減少し、空転・滑走検知信号がなくなるとある傾きで粘着力 T_μ まで復帰し、空転・滑走検知信号がなくなつて一定時間後に元の値まで戻るという動作を行う。

【0018】図 2 は、図 1 における車体速度推定演算部 5 の詳しい構成を示す。加速度演算部 21 は最低速度演算部 (MIN) 4 から入力された最小速度の加減速度を演算する。空転・滑走による急峻な加減速度を一次遅れフィルタ 22 で抑え、積分器 24 で積分することにより安定な推定速度を得る。加速度補正部 26 は積分器 24 の出力する推定速度と入力される最小速度との差を求め、加算器 23 において加速度演算部 21 の出力する加速度を補正し、積分器 24 の求める推定速度が最小速度から大きくかけ離れることを防ぐ。

【0019】最小値演算部 (MIN) 25 では、推定速度が最小速度より大きくなることを防ぎ、大きくなつた場合には、車体速度推定値が最小速度に一致するよう積分器 24 及び一次遅れフィルタ 22 をプリセットする。

【0020】図 3 は、図 1 における粘着力係数演算部 8 が実行する粘着力係数演算式の例を示している。レール乾燥時を 1.0 とすると、すべり速度 X が、 $X > X_0$ の領域では $Y = -A \cdot X + B$ で関数化できる。発明者の実験結果では、

$X_0 = 0.25 \text{ km/h}$, $A = 0.09$, $B = 0.83$ が得られている。

【0021】図 4、図 5 は、車輪に散水した条件で走行時の粘着力と、レール・車輪間のすべり速度との関係を測定した実験データを示す。これらの平均値を、レール乾燥時の値を 1.0 として変換し、すべり速度に対してプロットした特性が図 3 のグラフのようになる。

【0022】次に、上記の実施の形態の動作を、図 6 を用いて説明する。t 2 時点で空転・滑走検知部 2 により空転・滑走検知信号が発生すると、その時点の駆動トルク指令値 T_{ref} がトルク指令ラッチ部 11 により $T_{reflatch}$ としてラッチされる。その後、粘着力係数演算部 8 によりある傾きでトルク絞り量を増加させ、駆動トルク指令 T_{ref} を低減させる。t 3 時点で空転・滑走検知信号が解除されるまでの間の最大すべり速度 X_1 が最大すべり速度演算部 7 によって演算され、粘着力係数演算部 9 の出力 Y_1 は図 3 の特性により演算される。すなわち、最大すべり速度 X_1 により粘着力係数 Y_1 は、

$$Y_1 = -A \cdot X_1 + B$$
となり、空転・滑走検知時にラッチされた駆動トルク $T_{reflatch}$ に粘着力係数 Y_1 を掛けて、 $T_\mu = Y_1 \cdot T_{reflatch}$ で演算される。

【0023】t 3 時点で空転・滑走検知信号が解除されると、粘着力係数演算部 9 の出力は粘着力 ΔT_{adh} へ向かって減少するため、図中に示すように駆動トルク指令 T_{ref} は T_μ へ向かって上昇する。言い換えると、車輪がレールに再粘着し、空転・滑走検知信号が解除された時のトルク指令値は、空転を検知した時のトルク指令値に対して粘着力係数を掛けた値 T_μ になる。

【0024】本発明の第 1 の実施の形態によれば、トルク指令復帰前の最大すべり速度から粘着力を演算するので、最新のレール・車輪間の粘着状態を考慮した駆動トルク指令の復帰値の設定が可能となる。

【0025】次に、本発明の第 2 の実施の形態を、図 7 を用いて説明する。図 6 において、図 1 に示した第 1 の実施の形態と共通する要素には同一の符号を付してある。図 1 に示した第 1 の実施の形態に対して追加された要素は、復帰トルク保持部 17、すべり速度増大検知部 18、論理回路 19 である。

【0026】復帰トルク保持部 17 は、復帰停止信号によりトルク絞り量の減少を停止させる機能を有する。同じく追加されたすべり速度増大検知部 18 は、最大すべり速度演算部 7 の出力する最大すべり速度の増大を検知してすべり速度増大検知信号を出力し、論理回路 19 は、オフディレイタイマ 12 の粘着力保持信号に対する NOT 信号とすべり速度増大検知信号との AND を求める。復帰トルク保持部 17 は復帰停止信号によってトルク絞り量の減少を停止させる働きをするが、この復帰停止信号は、論理回路 19 の出力である、すべり速度増大検知信号と粘着力保持信号がないこととの論理積の条件で成立する信号である。

【0027】これにより、空転・滑走検知後、粘着力保持信号がなくなるまでは復帰停止信号は出力されないので、粘着力係数演算部 8 で演算された係数に基づく粘着力が確保される。発明者の実験結果では、復帰停止信号を出力するすべり速度のしきい値は 0.5 km/h 、復帰停止信号を解除するしきい値は 0.3 km/h 、粘着力保持信号を保持する OFF T D 12 のディレイ時間は 3 秒が好ましいという結果が得られている。

【0028】第 2 の実施の形態の動作を、第 1 の実施の形態と同様に図 6 を用いて説明する。t 5 時点で粘着力保持信号がなくなりトルク絞り量が減少を始めると、駆動トルクが上昇し、レール・車輪間の粘着力以上となる t 6 時点で、再び空転を始める。すべり速度が上昇し、復帰停止信号を出力するセット値以上になる t 7 時点で、トルク絞り量を減少させる動作を停止する。その後、すべり速度が復帰停止信号を解除するリセット値以下になる t 8 時点で、再び駆動トルク指令は上昇を始めると、

【0029】本発明の第 2 の実施の形態によれば、すべり速度を監視してトルク指令の増加を抑制するので、すべり速度が増加し、再び空転・滑走が発生するのを防止

できる。

【0030】次に、本発明の第3の実施の形態を、図8を用いて説明する。図1に示した第1の実施の形態又は図7に示した第2の実施の形態において、粘着力係数演算部8における粘着力係数Yの演算は、図8のグラフに示すような $Y = A / (X + B)$ により行わせることができる。これにより、最大すべり速度 X_1 と粘着力係数 Y_1 は、 $Y_1 = A / (X_1 + B)$ で演算される。ただし、A、Bは定数である。

【0031】図8は $B = A$ とした場合のグラフである。この図8によれば、最大すべり速度が増大するほど粘着力係数はほぼ反比例で小さくなる。

【0032】次に、本発明の第4の実施の形態について、図9を用いて説明する。図1に示した第1の実施の形態又は図7に示した第2の実施の形態において、粘着力係数演算部8における粘着力係数Yの演算は、図9のグラフに示すような $Y = -A \cdot X^2 + B$ (A, B定数)により行わせることもできる。これにより、最大すべり速度 X_1 と粘着力係数 Y_1 は、 $Y_1 = -A \cdot X_1^2 + B$ (A, B定数)で演算される。

【0033】図9は $B = 1.0$ とした場合である。この図9によれば、最大すべり速度が増大するほど粘着力係数はほぼ2乗に比例して小さくなる。

【0034】次に、本発明の第5の実施の形態について、図10を用いて説明する。図10は、図1に示した第1の実施の形態、図7に示した第2の実施の形態の電気車制御装置において、それぞれの空転・滑走検知部2に置き換えて採用できる空転・滑走検知部2の詳しい構成を示している。

【0035】本実施の形態の空転・滑走検知部2は、VVVF (可変電圧可変周波数方式) でNo.1軸を駆動している場合を示す。No.1軸の加速度を加速度演算部31で演算し、その出力を空転・滑走検知比較器32へ入力する。この比較器32は、入力される加速度が空転・滑走の検知しきい値を超えていたら「H」を出力し、空転・滑走検知信号作成フリップフロップ35のS入力にセットする。この結果、フリップフロップ35の出力である空転・滑走検知信号は「H」となる。

【0036】一方、最低速度演算部4の出力するNo.1軸速度～No.4軸速度のうちの速度最小値に対して車体速度推定部5が求める車体速度推定値を取り込み、加算器33において、No.1軸速度とこの車体速度推定値との差、すなわちすべり速度を求める。空転・滑走解除比較器34は、この加算器33の出力するすべり速度を入力する。そして比較器34は、すべり速度が空転・滑走検知信号作成フリップフロップ35のR入力にセットする。この結果、フリップフロップ35の出力である空転・滑走検知信号は「L」となる。

【0037】図11は、図10の空転演算部2による空

転・滑走検知方法を示している。No.1軸が空転し、その加速度が空転・滑走検知しきい値以上となると、空転・滑走検知信号は「H」となる。No.1軸が再粘着し、No.1軸速度と車体速度の差、すなわちすべり速度が空転・滑走信号解除しきい値以下となると、空転・滑走検知信号は「L」となる。この作用により、加速度のみで空転・滑走検知を行うよりも再粘着を確実に検知でき、再空転を防ぐことができる。

【0038】

【発明の効果】本発明により、空転・滑走時の再粘着特性が改善され、空転・滑走頻度が低減でき、電気車としての加速性能と乗り心地を向上させることができる。

【0039】特に、請求項1、3、4の発明によれば、電気車の空転又は滑走を検知してトルクを絞り、その後トルクを復帰させる再粘着制御を行う電気車制御装置において、駆動軸車輪の空転又は滑走を監視し、空転又は滑走を検知した時に、電動機の回転数信号より推定した車体速度と電動機の回転数信号より、駆動軸車輪のレールに対するすべり速度の最大値を演算し、さらに最大すべり速度をXとして、粘着力係数Yのすべり速度Xに対してあらかじめ設定してある関数 $Y = -A \cdot X + B$ (A, B定数)により、あるいは、 $Y = A / (X + B)$ (A, B定数)、あるいは、 $Y = -A \cdot X^2 + B$ (A, B定数)により粘着力係数を求め、空転又は滑走を検知して駆動トルクを絞り、その後駆動トルクを復帰させる目標値を演算する際、この粘着力係数が大きい時はトルクを復帰させる目標値を大きくし、小さい時はトルクを復帰させる目標値を小さくするようにしたので、最新のレール・車輪間の粘着状態を考慮した駆動トルク指令の復帰値の設定が可能であり、空転・滑走時の再粘着特性が改善され、空転・滑走頻度が低減でき、電気車としての加速性能と乗り心地を向上させることができる。

【0040】また、請求項2の発明によれば、電気車の空転又は滑走を検知してトルクを絞り、その後トルクを復帰させる再粘着制御において、電動機の回転数信号より駆動軸車輪の空転又は滑走を検知し、また電動機の回転数信号より車体速度を推定演算し、空転又は滑走を検知した時に、車体速度と電動機の回転数信号より、駆動軸車輪のレールに対するすべり速度を演算し、空転又は滑走を検知してトルク指令を絞り、その後トルク指令を復帰させる際、すべり速度が予め設定された値以上になったことを検知してトルク指令を復帰させる動きを停止し、その時点のトルク指令値を保持するようにしたので、すべり速度を監視してトルク指令の増加を抑制することができ、すべり速度が増加し、再び空転・滑走が発生するのを防止できる。

【0041】さらに、請求項5の発明によれば、車輪の加速度あるいは減速度があるしきい値を超えた空転・滑走検知信号をセットし、可変電圧可変周波数方式で駆動されている車輪と他の車輪との速度差があるしきい値

以下になつたら空転・滑走検知信号をリセットするようになつたので、加速度のみで空転・滑走検知を行うよりも再粘着を確実に検知でき、再空転を防ぐことができる。

【図面の簡単な説明】

【図1】本発明の第1の実施の形態のブロック図。

【図2】上記の実施の形態における車体速度推定部のブロック図。

【図3】上記の実施の形態において粘着力係数演算部が用いる演算式のグラフ。

【図4】上記の実施の形態において散水条件における粘着力とすべり速度との実測値を示すグラフ(その1)。

【図5】上記の実施の形態において散水条件における粘着力とすべり速度との実測値を示すグラフ(その2)。

【図6】本発明の第1の実施の形態、第2の実施の形態の再粘着制御特性を動作を示すタイミングチャート。

【図7】本発明の第2の実施の形態のブロック図。

【図8】本発明の第3の実施の形態において、粘着力係数演算部が用いる演算式のグラフ。

【図9】本発明の第4の実施の形態において、粘着力係数演算部が用いる演算式のグラフ。

【図10】本発明の第5の実施の形態における空転・滑走検知部のブロック図。

【図11】上記の実施の形態による空転・滑走検知動作のタイミングチャート。

【図12】従来例の構成のブロック図。

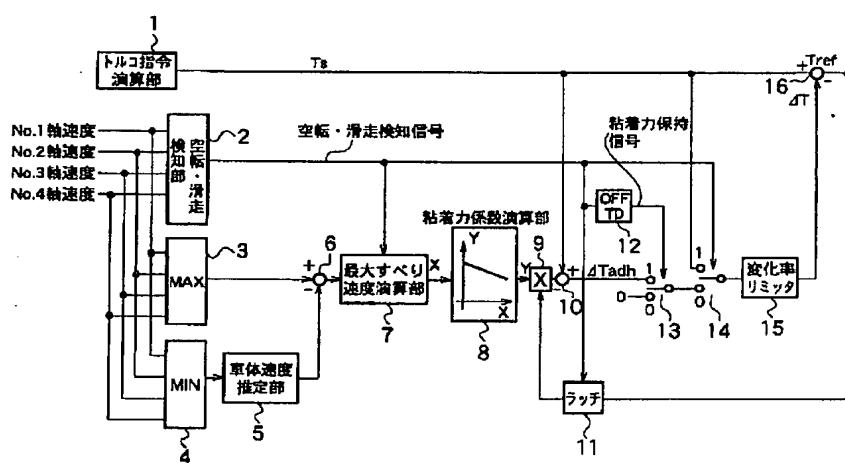
【図13】従来例の正義動作を示すタイミングチャート*

*ト。

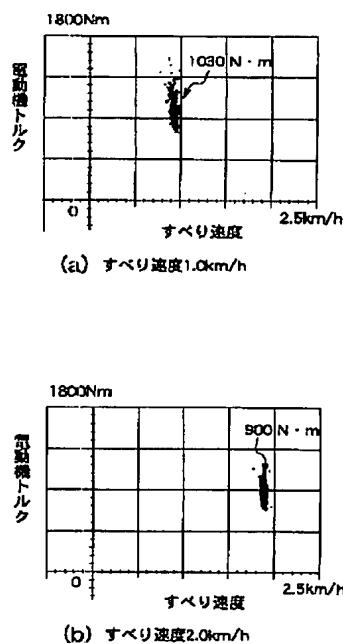
【符号の説明】

- 1 トルク指令演算部
- 2 空転・滑走検知部
- 3 最大速度演算部
- 4 最低速度演算部
- 5 車体速度推定部
- 6 加算器
- 7 最大すべり速度演算部
- 8 粘着力係数演算部
- 9 乗算器
- 10 加算器
- 11 トルク指令ラッチ部
- 12 オフディレイタイマ
- 13 紋り量切換スイッチ
- 14 粘着力切換スイッチ
- 15 變化率リミッタ
- 16 加算器
- 17 復帰トルク保持部
- 18 すべり速度増大検知部
- 19 論理回路
- 20 加速度演算部
- 31 空転・滑走検知比較器
- 32 空転・滑走解除比較器
- 35 フリップフロップ

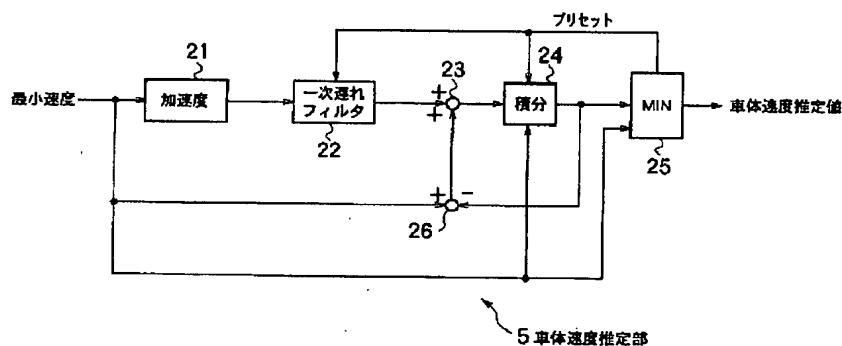
【図1】



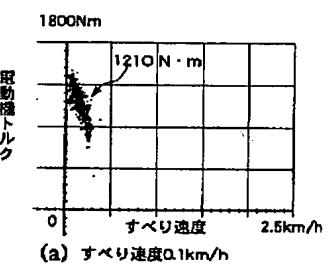
【図5】



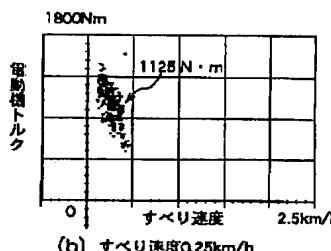
【図2】



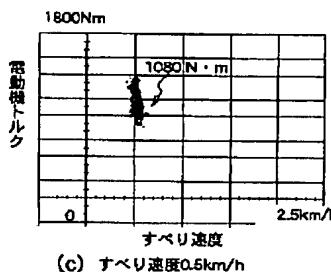
【図4】



(a) すべり速度0.1km/h

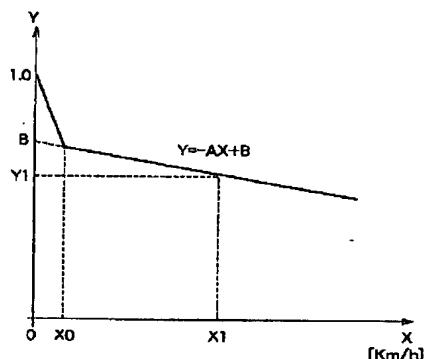


(b) すべり速度0.25km/h

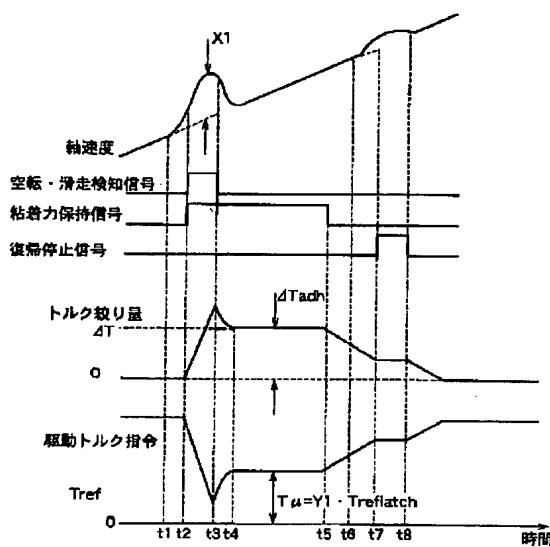


(c) すべり速度0.5km/h

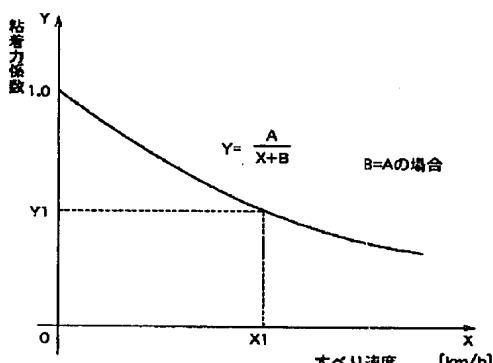
【図3】



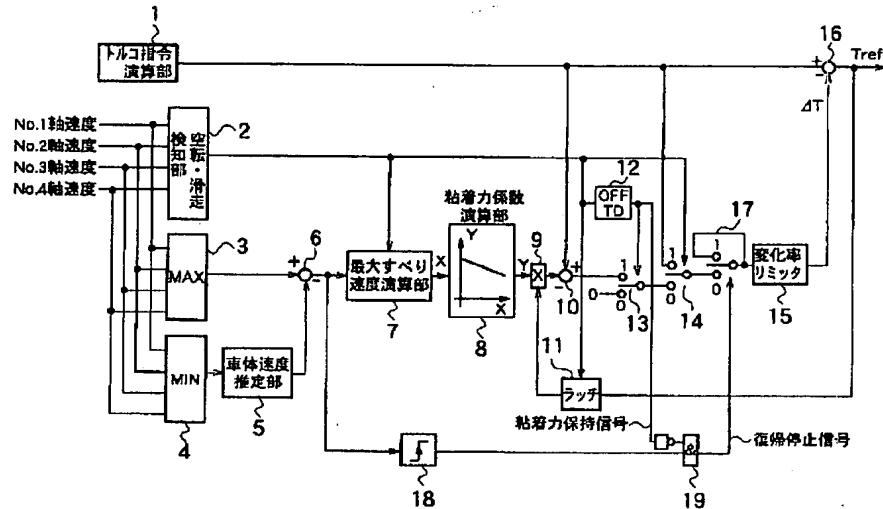
【図6】



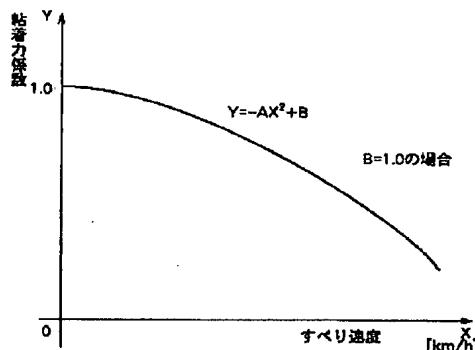
【図8】



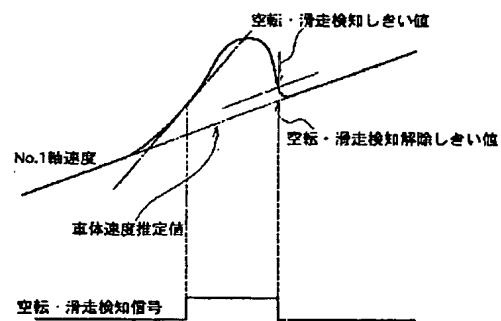
【図7】



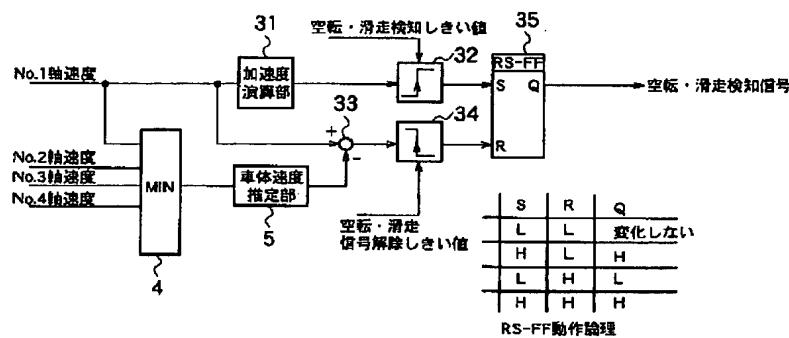
【図9】



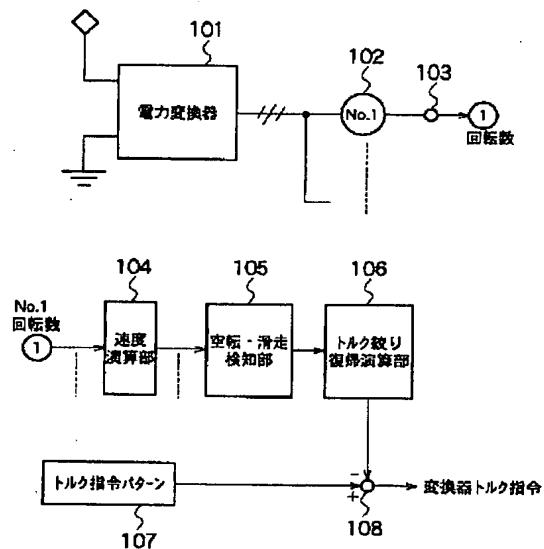
【图 1-1】



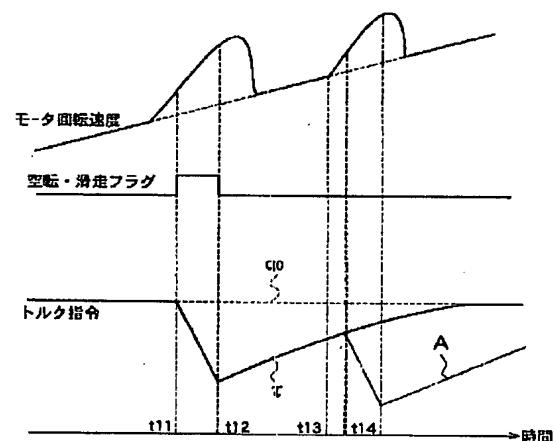
〔四一〇〕



【図12】



【図13】



フロントページの続き

F ターム(参考) 5H115 PA01 PA08 PC02 PG01 PI01
 PU01 QE14 QN06 RB24 SE03
 TB03 T004 T030